The Adaptive Patterns of Pelvic Alignment in Individuals with Adolescent Idiopathic Scoliosis

Laddawan Saetang Grad Dip*,
Prasert Sakulsriprasert PhD*, Mantana Vongsirinavarat PhD*

* *Faculty of Physical Therapy, Mahidol University, Nakhon Pathom, Thailand*

Objective: *To investigate the adaptive pattern of pelvic alignment and to determine the correlations between pelvic alignment and Angle of Trunk Rotation (ATR) of each curve type in individuals with Adolescent Idiopathic Scoliosis (AIS).*
Material and Method: *This cross-sectional study of 31 AIS subjects was divided according to single or double curve patterns. Demographic data and ATR were collected. Five-view photos were shot before using Scion Image Software to calculate pelvic alignment. Independent t-test was used to compare pelvic alignment between groups. Pearson's correlation coefficient was used to identify the correlation between pelvic alignment and ATR.*
Results: *The subjects with single and double curves, showed significant difference in the right sagittal and transverse planes (p = 0.021). The double-curve group showed significant negative correlation of anterior-pelvic-obliquity and ATR (p = 0.037), significant positive correlations of left-pelvic-tilt and ATR (p = 0.021), and right-pelvic-tilt and ATR (p = 0.005). The major-curve group showed significant negative correlation of anterior-pelvic-obliquity and ATR (p = 0.014), significant positive correlation of right-pelvic-tilt and ATR (p = 0.021), and top-pelvic-rotation and ATR (p = 0.032). The near-pelvis-curve group showed only significant negative correlation of anterior-pelvic-obliquity and ATR (p = 0.032).*
Conclusion: *Both AIS groups showed different pelvic tilt and rotation. ATR showed the correlation with pelvic tilt and obliquity in double-curve group only. A larger curve influenced the pelvic-spinal rotation relationship more than the near-pelvic-curve. Thus, awareness of pelvic alignment in AIS assessment and treatment is recommended.*

Keywords: *Idiopathic scoliosis, Pelvic alignment, Trunk rotation, Single curve, Double curve*

J Med Assoc Thai 2015; 98 (Suppl. 5): S119-S124
Full text. e-Journal: *http://www.jmatonline.com*

Adolescent Idiopathic Scoliosis (AIS) is a complex spinal deformity of lateral curvature and rotation, impacting the vertebral sagittal plane. AIS is commonly found between ages 10 and 18 years in orthopedic clinics(1,2) and observed as asymmetric trunk caused by spinal rotation, resulting in a rib hump on one side(3). Trunk asymmetry is determined by Angle of Trunk Rotation (ATR), a signature feature of clinical examination for scoliosis(3,4).

Common scoliosis curve patterns are: single and double curve, which occur at various areas(5,6). The pathological change is the failure of pelvic-spinal rotation control, that induces systemic changes of pelvic positions, and affects lumbar and thoracic spinal rotation(7,8). Thus, the pelvic position influences the spinal rotation and deformity pattern(9-11).

Correspondence to:
Saetang L, Physical Therapy Center (Pinklao), Mahidol University, 198/2 Somdejphapinklao Road, Bangyeekhan, Bangplad, Bangkok 10700, Thailand.
Phone: +66-2-4337098, Fax: +66-2-4337099
E-mail: laddawan.sae@gmail.com

The asymmetric pelvic alignment referring to frontal, sagittal and transverse planes are called pelvic obliquity, pelvic tilt and pelvic rotation, respectively(11,12). Commonly, AIS has misalignment of the pelvic position related with the curve patterns. According to Schaffer, pelvic anterior rotation on the shorter leg and posterior rotation on the longer leg result in C or S scoliosis curve(13). In addition, Gum et al(9) showed that the pelvic transverse rotation is significantly in the same direction with the main thoracic curve of both single and double curves. Thus, the pelvic position involves the scoliosis curve pattern. Nonetheless, the correlation between pelvic pattern and ATR of each curve type has not yet been studied in AIS. The purpose of study was to compare the pelvic alignment between groups and determine the correlation between pelvic alignment and ATR of each curve type with AIS.

Material and Method

The present study was approved by the Mahidol University Institutional Review Board (MU-

IRB COA. No. 2012/104.0211). The authors developed a cross-sectional research design and recruited the subjects from the Physical Therapy Center, Faculty of Physical Therapy, Mahidol University. Inclusion criteria included age between 10 and 18 years; diagnosed with AIS and the Cobb angle of greater than 10°; leg length discrepancy (LLD) of less than 15 mm; no foot deformity; and no pain at the time of evaluation. Exclusion criteria included historic surgical treatment for scoliosis, orthopedic surgery, central or peripheral neurological disorders and other spinal disorders.

All subjects were examined by a physical therapist to ensure their inclusion criteria before signing the consent form. The subjects were tape-measured, between the anterior superior iliac spine (ASIS) and medial malleolus in the supine position, for LLD of both legs.

The information collected includes demographic data, diagnosis of scoliosis type, degree of Cobb angle, apex of curve and ATR. The examination of ATR was administered using Adam's Forward-Bending test with scoliometer measurement[3]. Before the study, leg length and scoliometer measurement were assessed for their test-retest reliability by Intraclass Correlation Coefficient (ICC) 2-way mixed model at 95%; both results were 0.998.

To measure the pelvic alignments, a physical therapist placed two spherical wand markers (13 mm diameter) perpendicular to ASIS and two spherical markers (13 mm diameter) perpendicular to the Posterior Superior Iliac Spine (PSIS). Two identical cameras were used. One camera was fixed on the bar at 2.5 m above the floor for top-view pictures. The other camera was fixed on the tripod placed 2 m away from the subject, adjusted vertically to pelvic height of each participant. Vertical and horizontal level adjustments of the cameras were made for each set of photographs using a spirit level.

Each subject was instructed as follows: 1) Stand facing the camera (anterior view) in a comfortable erect position on the footboard with heels at the indicated line. Then the examiner marked the feet position, 2) Look straight ahead at a target 2 m away, 3) Keep both knees straight. Finally, 4) stand still during the photographing. The examiner took a picture in anterior and top view. Next, the footboard was turned 90° clockwise to capture the left, posterior, and right views.

Quantitative pelvic positions from the digital photographs were calculated with Scion Image Software to determine the pelvic angle in three planes. In the frontal plane, the pelvic obliquity was calculated using the angle between both the ASIS line and the horizontal line in the anterior view (Fig. 1-1), and between both the PSIS line and the horizontal line in the posterior view (Fig. 1-4). In the sagittal plane, the pelvic tilt was the angle formed by the line between the ASIS and PSIS of each side and by the horizontal line in lateral view (Figs. 1-3, 1-5). In the transverse plane, the transverse pelvic rotation was the angle formed by the horizontal line and by the both ASIS line in top-view (Fig. 1-2).

In this research, the five views and the click-on marker within the Scion Image Software were measured for their test-retest reliability using intraclass correlation coefficients ($ICC_{2,1}$). The results were 0.975 and 1.000, respectively.

Statistical analysis

SPSS Software version 15.0 was used to analyze the data. The statistical significance level was set at *p*-value less than 0.05. Descriptive statistics were used for demographic data, the diagnosis of scoliosis type, degrees of Cobb angle, pelvic position and ATR. The analyses were done by allocating subjects in groups according to curve pattern from radiography. Normal distribution of variables was tested by one sample Kolmogorov-Smirnov test. Independent t-test measurement was used to compare pelvic alignment between groups and Pearson's correlation coefficient was used to determine the correlation of the pelvic position and ATR in individuals with AIS.

Results

The minimum number of subjects from sample size calculation for each curve group was estimated to be eight subjects. Thirty-one subjects with AIS were recruited and categorized in two groups: single (n = 14) and double curve (n = 17). The independent t-test was used to compare all variables between groups. The

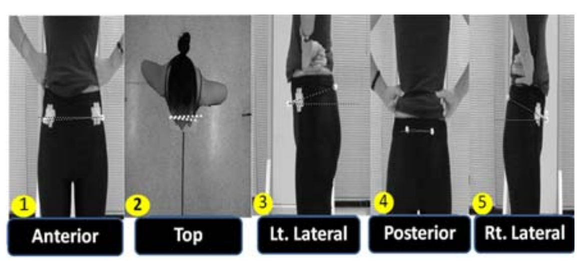

Fig. 1 Scion image calculation of pelvic alignment.

characteristics of subjects are shown in Table 1.

The pelvic alignments showed that the right and top views significantly differed between groups (p = 0.021 and p = 0.006, respectively). However, the differences in anterior, posterior and left view between the groups were not significant (Table 2). While the major curve of the single curve groups showed no significant correlations between pelvic pattern and ATR, the double curve groups showed a significant negative correlation of the pelvic obliquity-anterior view and ATR (r = -0.510, p = 0.0137), and a significant positive correlation of the pelvic tilt-left view and ATR (r = 0.554, p = 0.021) and pelvic tilt-right view and ATR (r = 0.643, p = 0.005) (Table 3).

The major curve of both groups showed significant negative correlations between the pelvic obliquity-anterior view and ATR (r = -0.438, p = 0.014), and significant positive correlations between pelvic tilt-right view and ATR (r = 0.413, p = 0.021, respectively), and pelvic rotation-top view and ATR (r = 0.386, p = 0.032). At the same time, the curve near the pelvis of both groups showed only significant negative correlations between pelvic obliquity-anterior view and ATR (r = -0.388, p = 0.031) (Table 3).

Discussion

Both scoliosis curve types were found in females more than males. Double curve had a greater Cobb angle and ATR (Table 1). Several studies[14-17] have stated that AIS rates differ by sex and age. Curve progression occurs more in the double curve group and among female subjects and larger curves were

Table 1. Characteristics of subjects for each group

Characteristics	Single curve group		Double curve group	
	n	Mean ± SD	n	Mean ± SD
Curve type (n)	8/1 (right/left thoracic) 2/0 (right/left thoracolumbar) 1/2 (right/left lumbar)		16 (right thoracic-left lumbar) 1 (left thoracic-right thoracic)	
Sex (female/male)	10/4		14/3	
Dominant side (left/right)	0/14		2/15	
Age (years)		15.00±2.00		14.24±1.99
Weight (kg)		46.50±10.76		44.41±7.58
Height (cm)		160.50±10.45		158.12±8.61
BMI (kg/m²)		17.90±3.00		17.66±1.77
Onset (years)		13.71±1.77		12.94±1.68
Duration (months)		16.50±16.86		18.12±17.24
Cobb angle (degrees)		24.00±11.73		43.00±17.58
ATR (degrees)		9.14±2.74		13.65±5.53

ATR = Angle of Trunk Rotation; BMI = body mass index

Table 2. Mean values and standard deviations of pelvic alignments for each curve type

Pelvic alignments (degrees)	Single curve (n = 14)	Double curve (n = 17)	*p*-value*
Frontal			
Anterior view	2.18±1.35	1.89±1.84	0.634
Posterior view	4.11±2.61	4.75±3.06	0.537
Sagittal			
Left view	12.79±5.43	14.49±4.43	0.345
Right view	14.35±5.52	18.65±4.32	0.021*
Transverse			
Top view	3.17±1.40	5.65±3.18	0.006*

* significant difference at *p*-value <0.05

Table 3. Correlation between pelvic pattern and ATR of each curve type major curve and curve near pelvis

Pelvic alignments (degrees)		ATR			
		Single	Double	Major curve	Curve near pelvic
Pelvic obliquity					
Anterior view	r	-0.269	-0.510	-0.438	-0.388
	p-value	0.353	0.037*	0.014*	0.031*
Posterior view	r	0.293	-0.154	0.019	-0.014
	p-value	0.310	0.556	0.920	0.940
Pelvic tilt					
Left view	r	-0.312	0.554	0.295	0.016
	p-value	0.278	0.021*	0.108	0.934
Right view	r	-0.354	0.643	0.413	0.087
	p-value	0.215	0.005**	0.021*	0.642
Pelvic rotation					
Top view	r	0.075	0.238	0.386	0.080
	p-value	0.798	0.357	0.032*	0.668

* Significant correlation at *p*-value <0.05, ** Significant correlation at *p*-value <0.01

more prevalent. The results of this study showed significant differences of pelvic alignment between groups in the pelvic tilt-right view and the pelvic rotation-top view (Table 2). The curve occurred mostly at the thoracic area in the single curve group, but at the thoracic and lumbar region in the double curve group. An imbalance at the lumbar area might cause the quadratus lumborum and iliopsoas muscles to work unilaterally, leading to spinal shift and rotation, influencing different pelvic rotations from the single curve group Similarly, for the sagittal-view, the muscles causing lumbar rotation resulted in concavity, and were likely to cause lumbar hyperlordosis that could influence different pelvic tilts between groups. The results are similar to Zabjek et al[18] that postural alignment in the transverse plane differed in single and double curve groups.

The double curve group showed significant negative correlations between pelvic obliquity-anterior view and ATR, and significant positive correlations between pelvic tilt-left- and -right-view and ATR. The single curve group was not present (Table 3). This result conforms to previous studies. Timgren et al[13] observed pelvic asymmetry related with scoliosis single or double curve. The scoliosis single curve was found at the elevated iliac crest, ipsilateral posterior rotation with longer leg and higher contralateral scapular. The double curve was found at the elevated iliac crest, ipsilateral anterior rotation with shorter leg and higher scapular on the same side. However, Salanova described the double thoracic-lumbar curve, which is thoracic dominant, where the pelvis is directly involved in the lumbar curve resulting in the iliac crest tilting to the convex side of the thoracic curve. However, when the pelvis is not involved, the lumbar curve results in the iliac crest tilting to the concave side of thoracic curve[19]. Furthermore, the correlation between pelvic rotation-top-view and ATR were present in the major curve of AIS but not in the curve near the pelvis. This showed that the trunk rotation in the larger curve could influence more than the curve near the pelvis. Gum et al[9] found significant pelvic transverse rotation in the same direction as the major thoracic curve in AIS with both single and double curves[9].

Limitations of this study included 1) no control group to compare results, and 2) the lack of simultaneous pelvic measurement in three planes. Despite the pictures not being taken in three planes as a single shot, a reliability test was conducted for accurate and consistent measurement before subject inclusion. This measurement was less costly and simpler to use in the clinic. For further study, the correlation of pelvic pattern and ATR of each curve type should be investigated in comparison with the control group. The pelvic measurement should consider the equipment that can collect and link data of the parameters in three planes simultaneously. Furthermore, AIS curve development can be studied long term and apply genetic and biological studies to help explain the findings, not only focusing on spinal and pelvic area, but also on foot and knee misalignment.

Conclusion

Clinically obtained ATR correlated the pelvic tilt and pelvic obliquity in the double curve group, but was not present in the single curve group. The relationship between transverse pelvic rotation and ATR were present in the major curve of AIS, while the curve near the pelvis was not present. It showed that the trunk rotation with the larger curve influenced more than the curve with near the pelvis. Thus, assessment and treatment for AIS, should be aware of and interested in correcting pelvic alignment to create a more effective approach for AIS.

What is already known on this topic?

The pelvic position influences spinal rotation and scoliosis curve pattern.

What this study adds?

Both AIS groups showed differences of pelvic tilt and rotation. ATR showed relationships with pelvic tilt and obliquity in the double curve group only. The trunk rotation in the larger curve influenced more than the curve near the pelvis.

Acknowledgement

My gratitude goes to the Physical Therapy Center, Mahidol University, and my colleagues for their supportive collaboration. I am also grateful to the subjects participating in this study.

Potential conflicts of interest

None.

References

1. Negrini S, Aulisa L, Ferraro C, Fraschini P, Masiero S, Simonazzi P, et al. Italian guidelines on rehabilitation treatment of adolescents with scoliosis or other spinal deformities. Eura Medicophys 2005; 41: 183-201.
2. Weiss HR, Negrini S, Rigo M, Kotwicki T, Hawes MC, Grivas TB, et al. Indications for conservative management of scoliosis (guidelines). Scoliosis 2006; 1: 5.
3. Bunnell WP. An objective criterion for scoliosis screening. J Bone Joint Surg Am 1984; 66: 1381-7.
4. Grivas TB, Vasiliadis ES, Koufopoulos G, Segos D, Triantafyllopoulos G, Mouzakis V. Study of trunk asymmetry in normal children and adolescents. Scoliosis 2006; 1: 19.
5. Cruickshank JL, Koike M, Dickson RA. Curve patterns in idiopathic scoliosis. A clinical and radiographic study. J Bone Joint Surg Br 1989; 71: 259-63.
6. Lenke LG, Betz RR, Harms J, Bridwell KH, Clements DH, Lowe TG, et al. Adolescent idiopathic scoliosis: a new classification to determine extent of spinal arthrodesis. J Bone Joint Surg Am 2001; 83-A: 1169-81.
7. Burwell RG, Cole AA, Cook TA, Grivas TB, Kiel AW, Moulton A, et al. Pathogenesis of idiopathic scoliosis. The Nottingham concept. Acta Orthop Belg 1992; 58 (Suppl 1): 33-58.
8. Burwell RG. Aetiology of idiopathic scoliosis: current concepts. Pediatr Rehabil 2003; 6: 137-70.
9. Gum JL, Asher MA, Burton DC, Lai SM, Lambart LM. Transverse plane pelvic rotation in adolescent idiopathic scoliosis: primary or compensatory? Eur Spine J 2007; 16: 1579-86.
10. Qiu XS, Zhang JJ, Yang SW, Lv F, Wang ZW, Chiew J, et al. Anatomical study of the pelvis in patients with adolescent idiopathic scoliosis. J Anat 2012; 220: 173-8.
11. Al Eisa E, Egan D, Deluzio K, Wassersug R. Effects of pelvic asymmetry and low back pain on trunk kinematics during sitting: a comparison with standing. Spine (Phila Pa 1976) 2006; 31: E135-43.
12. Baker R. Pelvic angles: a mathematically rigorous definition which is consistent with a conventional clinical understanding of the terms. Gait Posture 2001; 13: 1-6.
13. Timgren J, Soinila S. Reversible pelvic asymmetry: an overlooked syndrome manifesting as scoliosis, apparent leg-length difference, and neurologic symptoms. J Manipulative Physiol Ther 2006; 29: 561-5.
14. Galassi W, Sanboonlerng W, Dononsa J, Galassi M. A retrospective prevalence study of scoliosis in Thai adolescents. Thai J Orthop Surg 2006; 31: 33-5.
15. Reamy BV, Slakey JB. Adolescent idiopathic scoliosis: review and current concepts. Am Fam Physician 2001; 64: 111-6.
16. Anderson SM. Spinal curves and scoliosis. Radiol Technol 2007; 79: 44-65.
17. Nnadi C, Fairbank J. Scoliosis: a review. Paediatr Child Health 2010; 20: 215-20.
18. Zabjek KF, Leroux MA, Coillard C, Prince F, Rivard CH. Postural characteristics of adolescents with

idiopathic scoliosis. J Pediatr Orthop 2008; 28: 218-24.
19. Zabjek KF, Leroux MA, Coillard C, Rivard CH, Prince F. Evaluation of segmental postural characteristics during quiet standing in control and Idiopathic Scoliosis patients. Clin Biomech (Bristol, Avon) 2005; 20: 483-90.

การเปลี่ยนแปลงของกระดูกเชิงกรานในแต่ละรูปแบบความโค้งในผู้ที่มีภาวะกระดูกสันหลังคดโดยไม่ทราบสาเหตุในช่วงวัยรุ่น

ลัดดาวัลย์ แซ่ตั้ง, ประเสริฐ สกุลศรีประเสริฐ, มัณฑนา วงศ์ศิรินวรัตน์

วัตถุประสงค์: *เพื่อศึกษารูปแบบการปรับเปลี่ยนของแนวกระดูกเชิงกรานและความสัมพันธ์ ระหว่างแนวกระดูกเชิงกรานและมุมการหมุนลำตัวในแต่ละรูปแบบความโค้งของผู้ที่มีภาวะกระดูกสันหลังคดโดยไม่ทราบสาเหตุในช่วงวัยรุ่น*

วัสดุและวิธีการ: *การวิจัยแบบตัดขวางแบ่งผู้เข้าร่วมวิจัยที่มีภาวะกระดูกสันหลังคดโดยไม่ทราบสาเหตุ 31 คน เป็นสองกลุ่ม คือ ชนิด 1 และ 2 โค้ง โดยเก็บข้อมูลพื้นฐาน การหมุนของลำตัว ถ่ายภาพ 5 มุม และวิเคราะห์โดย Scion Image เพื่อหาแนวกระดูกเชิงกราน แล้วเปรียบเทียบระหว่างกลุ่มโดยใช้ Independent t-test และใช้ Pearson's Correlation Coefficient ศึกษาความสัมพันธ์ระหว่างแนวของกระดูกเชิงกรานและแนวการหมุนของลำตัว*

ผลการศึกษา: *ทั้งสองกลุ่มมีแนวกระดูกเชิงกรานด้านขวาและบน แตกต่างกันอย่างมีนัยสำคัญทางสถิติ (p = 0.021) กลุ่ม 2 โค้งมีความสัมพันธ์เชิงลบอย่างมีนัยสำคัญทางสถิติระหว่างด้านหน้าและการหมุนของลำตัว (p = 0.037) และมีความสัมพันธ์เชิงบวกอย่างมีนัยสำคัญทางสถิติระหว่างด้านซ้ายและการหมุนของลำตัว (p = 0.021) และระหว่างด้านขวาและการหมุนของลำตัว (p = 0.005) กลุ่มที่มีมุมความโค้งใหญ่เป็นหลักพบความสัมพันธ์เชิงลบอย่างมีนัยสำคัญทางสถิติระหว่างด้านหน้าและการหมุนของลำตัว (p = 0.014) ระหว่างด้านขวาและการหมุนของลำตัว (p = 0.021) ระหว่างด้านบนและการหมุนของลำตัว (p = 0.032) สำหรับกลุ่มที่มีความโค้งใกล้กระดูกเชิงกราน เป็นหลักพบเพียงความสัมพันธ์เชิงลบอย่างมีนัยสำคัญทางสถิติระหว่างด้านหน้าและการหมุนของลำตัว (p = 0.032)*

สรุป: *ทั้งสองกลุ่มมีความแตกต่างของแนวการหมุนหน้าหลังและแนวการหมุนซ้ายขวาโดยมุมการหมุนของลำตัว แสดงความสัมพันธ์ระหว่างแนวการหมุนหน้าหลังและแนวการหมุนบนล่างในกลุ่มกระดูกสันหลังโค้ง 2 โค้งเท่านั้น โดยที่ความโค้งใหญ่มีผลต่อการหมุนของกระดูกเชิงกรานและกระดูกสันหลังมากกว่าผลจากความโค้งที่อยู่ใกล้กระดูกเชิงกราน ดังนั้นจึงแนะนำให้ผู้รักษาประเมินและตระหนักถึงลักษณะแนวการวางตัวของกระดูกเชิงกรานในผู้ป่วยกระดูกสันหลังคดโดยไม่ทราบสาเหตุในวัยรุ่น*
